The imperatives for research implementation and delivery in Australia

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Abstract

Official policy promotes the view that Australia must invest strongly in strategic and applied sciences to maintain competitive edge within an increasingly global economy, where knowledge creation and use are seen as the key to future economic prosperity. Nevertheless Australia's small economy and research capacity mean that at best, Australia can never be more than a 'fast follower' in creating or acquiring new knowledge. This, plus the fact that over 70% of GDP is generated in the service sector, may explain why there is a credibility gap between rhetoric and actual proportion of government or private sector expenditure in R&D. Agricultural science is better supported by combined government and industry funding than most other sectors, and there is thus an expectation that this should lead to a more efficient and competitive agriculture sector than with those that are more reliant on government funding alone. While research supporting the supply side of agriculture performs well, those areas on the demand-side of the value chain are less well supported, and much Australian agricultural R&D remains conventional and emeshed in traditional organizational loyalties.

Media Summary

Joint investment in R&D does not inevitably lead to competitive agricultural performance. Market research and product development need more investment, for global competitiveness, while lack of alternative land uses force many small farmers into non-profitable conventional farming.

Key words

Commercialisation, innovation, sustainability, creativity, partnerships.

Introduction

When considering the title of this session, I found myself grappling with a dilemma. Clearly, in the context of the Australian Agronomy Conference and International Crop Science Congress, I would be expected to devote myself to agricultural matters, yet the title given left me gloriously free to consider research implementation and delivery across all disciplines and areas of human endeavour. Availing myself therefore of the license afforded by the title of the session, I have taken a broad canvas, and hope that this will produce some interesting comparisons, challenging some of the assumptions that are hidden in the title itself.

The True Believers

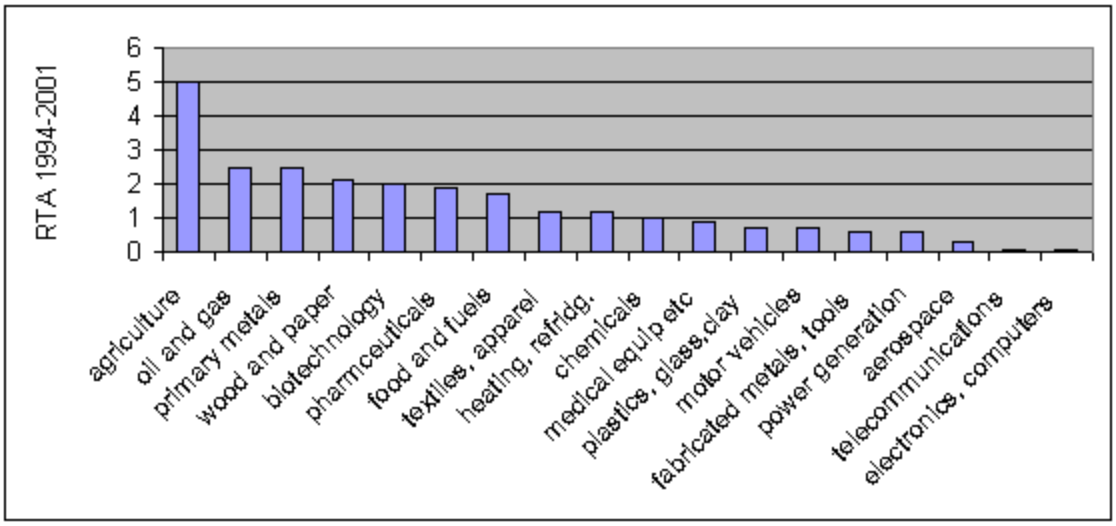
For several years, innovation has been the catch cry for western countries' science and technology policies. As expressed by British prime minister Tony Blair, 'Innovation, the exploitation of new ideas, is absolutely essential to safeguard and deliver high-quality jobs, successful businesses, better products and services for our consumers, and new, more environmentally friendly processes' (H.M. Government of the United Kingdom 2003). Investment in research for innovation is thus seen by western governments today as the critical strategy for maintaining competitive advantage in a globalised economy. The Australian federal government's most recent science white paper (Government of Australia, 2002) similarly identifies innovation as the key driver of science, technology and engineering, and argues that as goods, services and processes become more knowledge intensive there is increasing need for productivity gains based on such innovation for Australia to remain competitive in a knowledge-based

economy. Many of the phrases used in promoting this policy in Australia are uncannily similar echoes of policies described by the OECD and its individual member countries (OECD 2003).

The belief that a strong research and development capacity is imperative in maintaining and improving competitiveness and our high living standards against the pressure of cheap goods and services flowing from the developing world seems ubiquitous among western governments. It is however, only one strategy among many to protect our privileged position in the world. Financial incentives for investment and business opportunity, legal protection and control, the taxation environment, labour relations, infrastructural support are all necessary government strategies needed to stimulate economies, without which no amount of money poured into research and development is likely to have much impact. Indeed, with more than 70% of GDP in OECD countries coming from the service sector, and less than 2% of GDP invested in science and technology by all but the top performers in the league (Scandinavian countries, Japan, Korea and the United States spend more than the average), it is surprising that there is such government faith in the efficacy of science and technology.

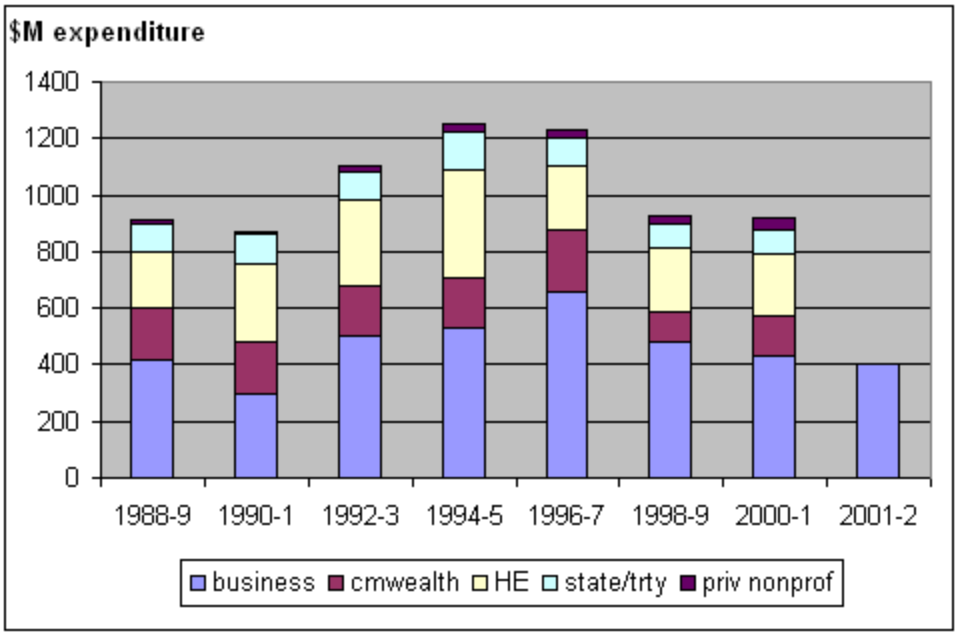
If we broaden the criteria from science and technology to *knowledge-generation* (another favourite buzz phrase in current science policy), which includes the amount invested in R & D, software and higher education, then this low figure increases to an average 4.8% for the OECD as a whole, and up to 7% for the USA. As a small country in population and economy, Australia is faring reasonably well in terms of measures of scientific performance, being in the middle of the range in some areas, and punching above its weight in others: ranking 9th out of 21 OECD countries in total numbers of research publications, 8th on a per capita basis, and contributing 2.9% of world's output in science and related discipline publications. Citations are higher than average in several areas of physical, medical and biological sciences, and the most highly cited scientists are in plant and animal sciences (i.e. agriculturally related) and geosciences where Australia has had long experience and vested interests. This is all good news in terms of research output, but does not tell us a great deal about implementation and delivery into knowledge-based industries. Indeed, publication *numbers* are not a very good guide to scientific leadership or capacity at all. An analysis of Australia's revealed technological advantage[i] compared with other countries is summarised in Figure 1. This work by Scott-Kemmis (2003) shows agriculture to be head and shoulders above any other technology sector, with a relative score of 5, as against the next highest sectors – primary metals, oil gas and mining with scores of only 2 to 2.4. Yet medical sciences have a publication record of nearly 8,000 peer reviewed articles per year, as against agriculture's 2,400. If reality matches rhetoric, the competitive advantage in technology demonstrated in agriculture should be matched by the superior economic performance of this sector over other technology based sectors. This however, is not the case. Growth rates in economic activity are twice as high in information and computer technology (ICT), for example.

Figure 1: Relative Technology Advantage (RTA) of technical sectors in the Australian economy (after Scott Kemmis, 2003).



In most of the advanced western countries the proportion of government expenditure in R&D is falling and private sector investment has grown strongly in the past decade. For the OECD countries as a whole the proportion has fallen from 36% in 1990 to 27% in 2001 (OECD 2003), while the proportion of private investment has risen to an average of 70% of all investments and 1.6% of GDP. This level of investment by the private sector is something that has persistently eluded us in Australia, where the picture is very different. The contribution of the private sector in Australia peaked at 0.86% of GDP in 1995, and has since fallen to 0.78%, or only 47% of R&D expenditures (Figure 2). This low level of private sector investment causes much wringing of hands, but also some hand-waving in policy circles. The government's white paper (Government of Australia 2003) explains this low level of private sector investment as the result of the unusual proportion of small to medium businesses in Australia, the predominance of the service sector, and, rather coyly almost as a last breath, mentions the low level of government incentives (only half that of leading OECD countries). This last reason is particularly pointed when looking at the drop in investment from 1996 onwards when the tax exemption base for R&D was lowered from 150 to 125%. In other words, Australia is failing to provide the right enabling environment to suit the particular strengths and needs of our economy, while subscribing to the same economic and scientific policy doctrines of the big boys on the OECD block.

Figure 2. Real capital R&D expenditure 1988-9 to 2001-2 (unpublished ABS data, quoted by Commonwealth of Australia, 2003 . Figures for categories other than business not available for 2002).



The federal government's recent evaluation of Australian science capacity made strong claims for the importance of science and innovation in contributing to economic growth, environmental sustainability and social well-being, with many somewhat platitudinous statements on providing the tools to manage risk, solve complex problems and adapt to change (Government of Australia 2003). As a small country remote from the Euro-American axis the government paper argues that the only sensible strategy for Australia is to be a 'fast follower', in which new knowledge and innovations generated elsewhere can be taken up rapidly, while seeking competitive advantage in areas where there are problems and opportunities unique to Australia. This is an admirable strategy, whereby we should be making every effort to join rather than compete with the 98% of science and technology produced off-shore, and which would see investments channelled strongly into specifically Australian strengths and weaknesses. The downside is that there is not much internal consistency in the implementation of such a strategy.

The federal government partially acknowledged the need for more money for science health and medical research in 2000, addressing anxieties that the scientific and academic community were then expressing over the slow deterioration in the public funding of science up to that time. However, although the investment in medical and health research has been doubled in the past four years, other areas have had no serious increases in funding and many are only just maintaining parity with pre-1999 years. Thus, despite the rhetoric expressed in the government's policies, this has not been matched by their action, in contrast with some other OECD countries which are now are investing more and faster in all aspects of science and technology; Canada by additional $2 billion per year, and UK from 7 to 10% growth in science budget per year. In Australia, by contrast, total proportion of GDP invested in science and technology from all sources has fallen from 14% in 1988-9 to 9% in 2000-1. The Federation of Australian Scientific and Technological Societies (FASTS 2004) sees this as an urgent and anxious issue when the European Community, for example, has recently set targets for increasing investment in research to 3% of GDP by 2010, that is, twice Australia's current rate.

Competition or Collaboration?

Governments traditionally invest in public sector research where there is market failure and where there is a need to build infrastructural capacity, such as specialist national centres for big ticket asset items in astronomy, nuclear physics, advanced medicine and biotechnology. These areas are foundation research requirements that are not attractive to most of the commercial sector in any country, other than where large multinational companies have developed very substantial basic research capacity in targetted areas, - such capacity hardly exists in Australia. Indeed, as statistics on private sector investment

demonstrate, Australian science and technology development is still dogged in general by market failure at that critical juncture between proof of application, venture capital investment and full commercialisation, shown in Figure 3.

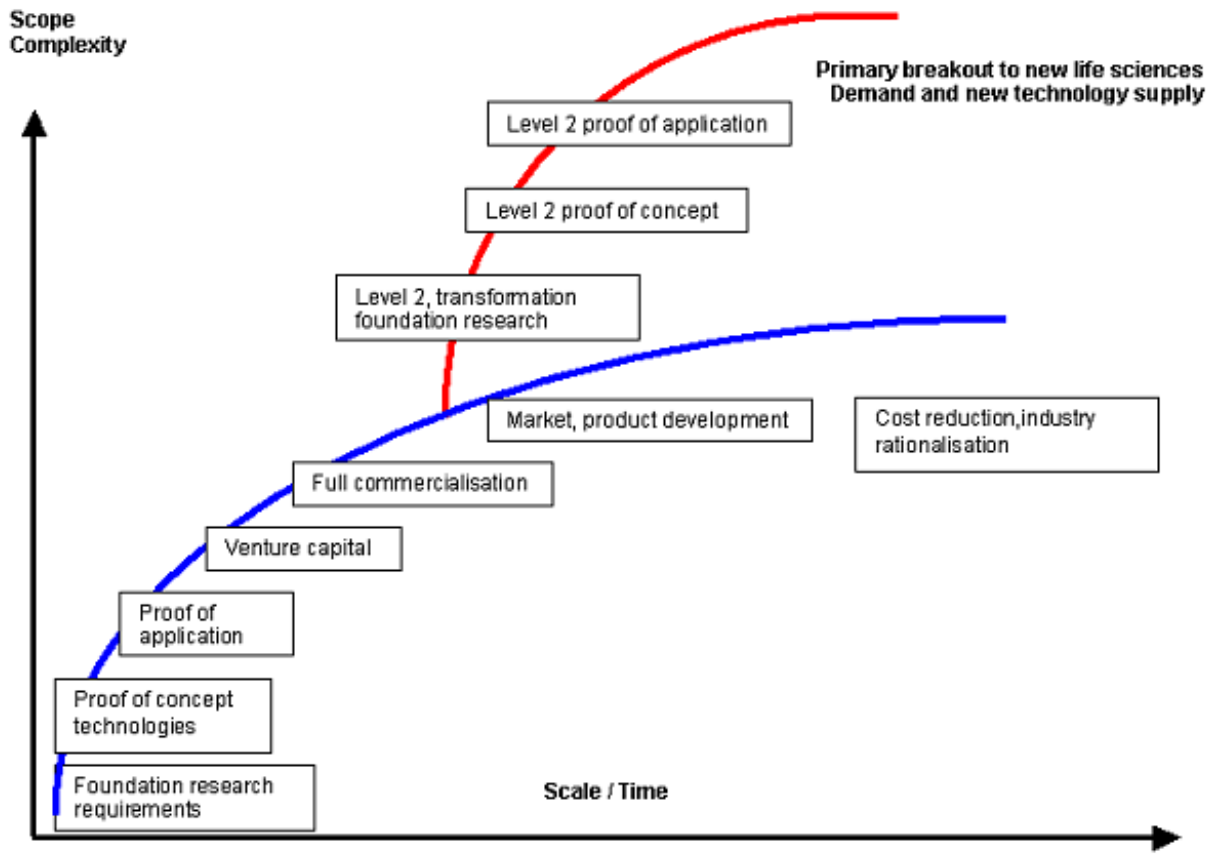


Figure 3. An industry development and transition cycle (after Pocknee and Associates, 2004).

Time and again this is where bright ideas, innovative products, and novel constructs move offshore or to multinationals, (remember 'gene-shears'?). This 'development' phase takes on average ten times the investment of the 'research' phase, yet most of our so-called R&D funding goes fair and square into the research side of the equation. Reasons for this are often ascribed to the small size of Australian businesses which restricts the capacity for high-risk development investment by companies that are focussing on short-term profitability and survival, and the high proportion of business activity in Australia devoted to the service rather than the manufacturing sector (Commonwealth of Australia 2003). The risk for investment in these stages is relatively low for the mixed government-plus-private RIRC and ARC funds however, yet even here, the proportion of grants allocated to proof of application and full collaborative partnerships for commercialisation remain low. For the Australian grains industry for example, which is the case being discussed by Pocknee and Associates (2004) in Figure 3, the authors argue that the present state of the industry has reached a plateau in which further market development along traditional lines will only provide marginal competitive benefits (continuing along the blue line), and that the industry must look more aggressively towards a completely new product range and set of markets that require a second phase of foundation research comparable with any new industry (Level 2, the red line).

In my experience, vested interest, or more charitably, an unwillingness to move out of their comfort zone, of the researchers themselves and the farmers who make up the majority of RIRC Boards and research agency managers remains a major constraint to research implementation in the agriculture sector.

Numerous surveys and prioritization exercises are undertaken at regular intervals to identify new R&D emerging issues and innovation initiatives for the rural sector, and just as regularly the responses returned place high priority on improvements in on-farm production; new varieties of crops, methods of pest, disease and weed control, improved machinery, automation and data logging systems, are highly valued. To give a specific example, in the past two decades Australia has produced an expanding range of pasture legume varieties for grazing and mixed farming systems, but apart from the adoption of serradellas and lucerne in the Western Australian grain belt, few of these have been widely commercialised or sown to improve pasture productivity and soil fertility (G. Bender pers. com.). The problem has been in creating the correct enabling environment for commercial seed companies to gain benefit from the new releases which have nearly all originated from government research agencies supported by RIRC funding. Despite individual researcher and agency interest in promoting particular cultivars, there has been no overall culture of commercialisation or coordinated business model for the pasture seed industries in Australia. To improve this situation, a critical path analysis would show the need for several coordinated steps, which include market research to identify target markets and their sizes both in Australia and internationally, the use of this market intelligence to set future R&D priorities and select varieties for commercialisation, a national seed production capacity development program, quality assurance procedures, product promotion and sales support, linked to agronomic management available as part of the commercialisation packages.

'Foundation' science, on the other hand, does require substantial basic and basic-applied research that has traditionally been the role of government funding, and in many OECD countries this has largely been the preserve of advanced research institutes embedded in universities, apart from research associated with national defence and security under direct government control. But in Australia the level of government control and investment extends much more widely because the peculiar position and strength of CSIRO, although it also includes such institutions as the Australian Institute of Marine Science, the Bureau of Meteorology, Geoscience Australia and State research agencies. Few other countries still invest so much of their public sector research money into non-university institutions. Is this level of direct government science support to dedicated government institutes separate from the private sector really the best way forward today? Despite the very high esteem with which organisations such as CSIRO are held, it is interesting to speculate whether government policy is not actually anti-competitive in allocating protected budgets to institutions such as CSIRO, which can then compete for further discretionary grants against universities, without having to contribute to the wider creation of knowledge through education as the Universities do, or having to undertake a regulatory role, as do the State research agencies. Instead of spreading the jam thin over a plethora of universities, federal and state government agencies, there might be better linkage and uptake of research through the development stages and full commercialisation if the money invested in specialist government research insitutions were channelled into more incentives for universities and private sector to work together more consistently and strongly, and for a greater range of incentives for private sector research investment as a whole.

A start has been made over the past decade through the Cooperative Research Centres program, but even here, it is interesting how many of the currently funded CRCs have objectives and outputs that are focussed on the public good (at least sixteen of the eighteen environmental CRCs, and four of the nine medical CRCs out of a total of sixty six). The CRC program has been hailed as a major success in stimulating university engagement with industry, and indeed, some of the CRCs have been outstandingly successful in developing key innovations that have far-reaching consequences. The CRCs for Choclear Implant and Hearing Aid Innovation and the CRC for Eye Research and Technology have produced ground-breaking new prostheses that are world-firsts. In the agricultural sector the CRCs have had few such totally novel breakthroughs, but the CRC for Sustainable Aquaculture of Finfish, the CRC for Viticulture, and the CRC for Sustainable Rice Production are all tightly tied into their respective industries and have been associated with very significant increases in profitability and expansion of these industries since their inception.

The Australian Research Council's 'linkage' program is also designed to bring industry and universities together, but the elaborate and time-consuming nature of the application process and the rather low level of success (less than 20%) of the competitive bids often discourages and frightens off many of the

younger, innovative and risk-taking scientists who should be just the ones to be encouraged to be making the links. Unforunately, with more than forty universities in Australia, and only sixty-six CRCs, in which the majority are located among the top eight 'brownstone' academic institutions, the present government programs designed to draw industry into the orbit of universities are just insufficient in scope to affect all but a minority of universities and businesses.

It would therefore seem that private sector investment in R&D in Australia needs much greater government commitment to strengthening the path to commercialisation via incentives for venture capital, tax exemptions and other fiscal measures, with the development of more company incubators, technology parks and similar joint ventures in association with universities. Such partnerships might then develop a truly collaborative approach to R&D that would fit the special characteristics of Australia's business sector, and allow for wider involvement across the full scope of university disciplines, including arts and the humanities.

The push-me-pull-you animal

I have argued that the present structure of the Rural Industry Research and Development Corporations, with their strong farmer representation on the boards and panels, has led to a preponderance of research investment concentrated on immediate benefits for the production part of the value chain, and less investment in post-farm value-chain and food processing development stages. Nor is there anything like the investment in research for sustainable farming ecosystems that could be expected from the 50% of the Corporations' budget contributed by the taxpayer for issues of common good. The traditional collection of separate levies for marketing (quite different from market research) and for R&D may well have compounded the problem of investment in post-farm aspects in industries, such as wool, meat and some horticultural crops, by seeming to make post-farm gate commercialisation something the marketing authorities would take care of.. The relatively low level of real RIRC expenditure on environmental management and issues of ecological sustainability however, reflects the difficulties that result from making Dracula the keeper of the blood bank, so to speak.

Thus, the proportion of research effort that is directed towards real alternatives to present farming systems and natural resource uses is small, and in practice much of the responsibility and leadership rests with the two corporations that have very limited budgets to tackle the scale and complexity of the issues involved: Land and Water Australia ($12M from government appropriations), and the Rural Industries R&D Corporation (approximately $14M appropriation in 2003). Typically, this distribution of research funds, focussing on commodities and production research represents science (and producer) 'push' rather than market, consumer *or community* 'pull', and is the cause much heartache and tension between these semi-autonomous R&D brokerage corporations, and the responsible government departments. Government and environment groups are not strongly represented on Boards and Committees of R&D funding bodies, and even then, government representatives have the difficult task of balancing the desire of government to foster competitive innovation, and government responsibility to protect public goods (natural resource assets). 'What' says the Auditor General's Office 'are you doing with government money that is supposed to be leading to more patents, more industrial innovation, more sustainable environmental management *and* more community satisfaction? Demonstrate your accountability!'. And indeed, over the twenty-five years of my own involvement with these corporations, both as researcher and as a member of their boards, there has been an ever-increasing requirement to demonstrate 'accountability'. What is not always clear is whether all this accountability has led either to more innovative research, more profitable farming, or more sustainable resource management.

Concern about value for money thus come primarily from central government. There is less concern from taxpayers, as community trust in scientists is still considerable in Australia, in sharp contrast to the situation in countries such as Britain where a series of scientific miscalculations, political blunders and poor handling of emergencies such as the BSE (bovinspongiformis-encepholytis) disaster, the foot and mouth outbreak in 2000, and adverse press on GM-crops has led to profound mistrust in public and private sector plant and animal scientists. In Australia there has been much talk about 'partnerships' in R&D, but with the track record of the way this has been interpreted by the Natural Heritage Trust , there is little joy for the private sector in that direction. The only partnership that seems to be apparent to those

outside the system is one of State and federal governments working in an uneasy alliance to secure on-going funding to cash-strapped State agencies. What would be truly exciting would be to see a genuine Trust or perpetual Foundation set up, in which there are incentives for private investment and income streams directed into national environmental priorities, so that Australian landholders and others in the private sector can be both investors and beneficiaries. Given the sheer size of the continent and the range and complexity of the environmental issues in Australia, and the pitifully small proportion of the population that is attempting to tackle them, such a trust might hold out some hope of moving beyond the grant-and-volunteerism policies that Australian governments have relied upon over the past two decades to cure some of our environmental ills.

Is sustainability a dirty word?

Future scenarios for Australian rural industries frequently start with assumptions that there will be a uniform progression towards greater productivity and more sustainability provided best management practices advances in research are ever more widely adopted. This has, after all been the basis to the success of the wine, cotton, aquaculture and other commodity-based sectors over the past decade. However, as the recent state of the environment reports for Australia have demonstrated, the condition of small areas (in all less than 2 million hectares) of productive irrigated land used for specific high-value industries cannot be used to judge the extent of natural or modified ecosystem integrity and resilience across a continent (Commonwealth of Australia 1996, 2001a). By far the largest land-use in Australia is pastoral grazing, and the condition of much of this land is deplorable, both from an agricultural productivity standpoint and from a biodiversity perspective **(**Graetz et al, 1995, Wilcox and Cunningham 1994, Commonwealth of Australia 2001b). In the more intensive land use zone, within the grain and mixed farming belt, there are an estimated 95 million hectares of improved or sown pastures and 20-25million hectares of cropland that are, to different degree, in need of better environmental management, and in which over 70-80% of farmers will never contribute more than a minor proportion of the total value or volume of crop and stock products.

Present R&D priorities, with their strong emphasis on maximising export-quality product geared to the top end of the market, appears to be failing these farmers and their need for long-term financial and environmental sustainability, just as much as the lack of venture capital investment is failing the large agri-businesses and corporate sector responsible for the majority of rural exports. Rather than developing R&D portfolios that assume all farmers are full-time, business-oriented, keen to adopt Best Practice Management (BMP) and focussed on increasing their export-quality produce, there is an equal need to identify the different priorities for small and medium farm businesses, recognising that off-farm income now supports more than half the total number of primary producers, and that more than fifty percent of the land farmed in Australia is unprofitable (National Land and Water Resources Audit, 2002). For some of these land managers alternatives such as low-input land uses, eco-tourism, bush tucker and wildlife enterprises, and agro-forestry may be more attractive options for reasons of both social and environmental sustainability, while for others, becoming paid stewards of the natural environment could be attractive, if it allowed them the opportunity to remain in their known localities. Tentative schemes for such alternatives have been promulgated from time to time, as in the Murchison-Gascoyne basin in Western Australia, and the Bush-for-Tender scheme in Victoria, but their adoption has been small-scale and episodic in the face of the juggernaut of traditional interests and the persistent myth of the moral virtue of rural development.

Conclusions

Australia has adopted the general OECD accepted wisdom that investment in science and technology will lead to the sorts of home-generated innovations needed to support a competitive manufacturing and servicing base to the country's economy, and that this is needed to achieve economic viability in a global economy. The evidence of past decade, in which sustained growth in the Australian economy has been based largely on expansion in the service and non-manufacturing sectors does not appear to support this argument well, but is eagerly advocated by scientists as well as governments as a revealed truth. Agriculture, because of the its paramount position historically in the Australian economy, has a commanding position in its reveal technology advantage over other technical sectors in the economy, but

current R&D tends to be weighted too much into conventional production systems, and too little into either wholly new types of land use to serve the needs of the unproductive and least profitable half of the sector, or into the proof of implementation and commercialization stages for novel developments in new phases of the industry that are needed by large agri-business interests to maintain their competitive lead in international and export markets. One imperative for much R&D in agriculture therefore is to overcome long-term vested interests of both research agencies and farmers for risk-averse government-funded production-based research in favour of greater investment more innovative alternative systems and product developments.

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[i] A Revealed Technology Advantage is the ratio of relative share of patents in a particular technological field over the relative share of patents for that technology field for the world as a whole.